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1968

A TRAINING AID ON DWARF MISTLETOE AND ITS CONTROL

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EXPERIMENT STATION

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE - REGION 2

A TRAINING AID ON DWARF MISTLETOE AND ITS CONTROL

By

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Revised and Adapted for Region 2

By

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FOREWORD

This training aid has been prepared to provide forest resource managers with basic facts about dwarf mistletoe and to furnish them general guidelines for its control so that sound decisions can be made. It was originally written for Region 6, but this copy has been revised for Region 2.

Progress in silvicultural control of dwarf mistletoe depends on how well our field personnel understand the nature and extent of the dwarf mistletoe problem, the life history, host-parasite relationships, the basis for silvicultural control, and the purpose and strategy of our control efforts.

Every effort has been made to incorporate the most recent information on dwarf mistletoe, its behavior and control. Based on our current knowledge, the information provided is sound. However, important advances in control procedures are continuously being made and improved methods are expected during subsequent years.

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INTRODUCTION

This training aid has 24 charts each with a writeup that describes and amplifies the material illustrated on the charts. Charts I to VIII concern facts about the dwarf mistletoes, their description and behavior. Charts IX to XII illustrate factors that must be considered and decisions that must be made before entering into a control program. Charts XIII to XXIV outline the basic principles of control.

Not all facets of the dwarf mistletoes and their control are given. However, an attempt has been made to include the major highlights necessary to assist the forest resource manager responsible for dwarf mistletoe control to make logical decisions so that control operations are both pathologically and silviculturally sound. Control procedures discussed will apply in a general way to any species of dwarf mistletoe on any host tree. However, most of our experience with the dwarf mistletoe problem has been in ponderosa pine; therefore, procedures are oriented toward control in this tree species.

Many statements, ideas, and procedures incorporated in this training aid were taken from various publications and other sources. Credit is given to the many authors, research workers and control officers whose writings and consultation have contributed to this training aid.

DWARF MISTLETOES OF COLORADO & WYOMING

GENUS:

ARCEUTHOBIUM

SPECIES:

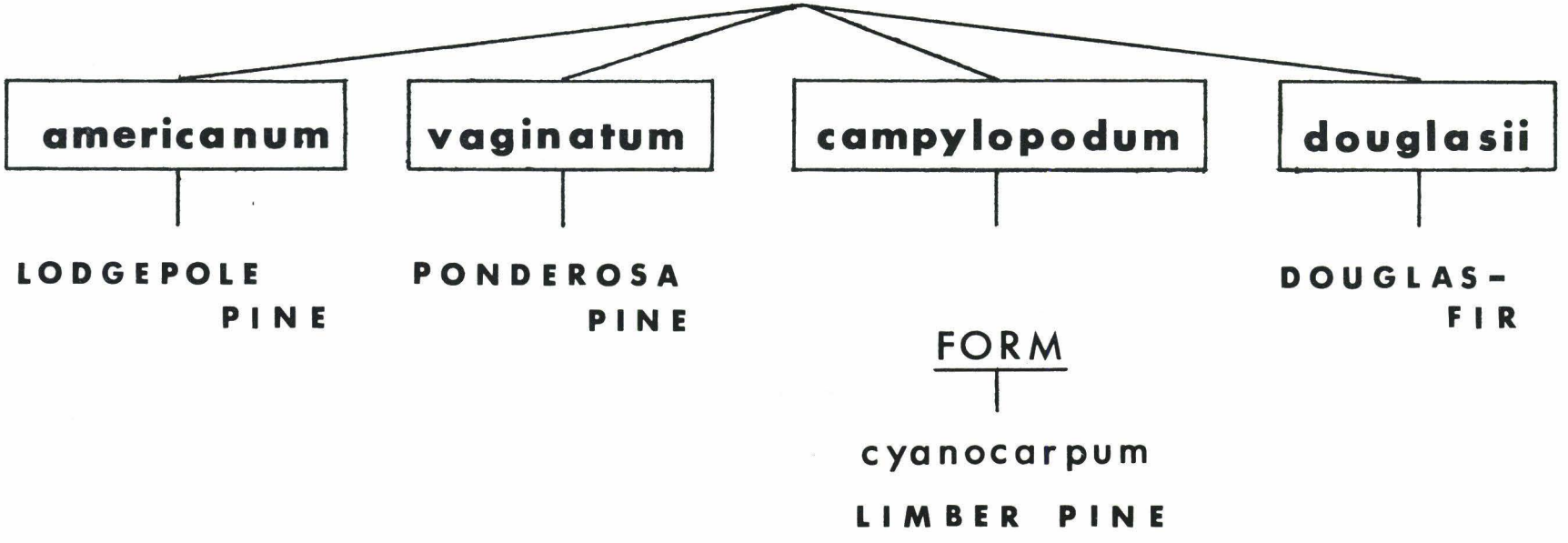


CHART 1

DWARF MISTLETOES OF COLORADO AND WYOMING

The dwarf mistletoes belong to the genus **Arceuthobium**. In the United States dwarf mistletoes are restricted to coniferous hosts in the Pinaceae family, that is, pine, Douglas-fir and true fir, larch, spruce, and hemlock. Dwarf mistletoe doesn't attack cedar, juniper, yew, and cypress in this country.

The four major species of dwarf mistletoe, their host trees and general distribution in Colorado and Wyoming are as follows:

1. Species **americanum**—The principal host is lodgepole pine and it occurs throughout the range of this host. It is occasionally found on ponderosa pine and limber pine usually where these trees are growing in association with lodgepole.
2. Species **douglasii** —Occurs on Douglas-fir in the southern half of Colorado and extreme western Wyoming.
3. Species **vaginatum**—Principal host is ponderosa pine. It occurs in the southern half of Colorado and into northern Colorado on the east slope of the Rockies.
4. Species **campylopodum** f. **cyanocarpum**—The principal host is limber pine. It occurs throughout the range of the host in Wyoming and into Colorado along east side of Rockies.

Note:

Although conifer timber types occur in South Dakota, Nebraska, and Kansas they are not known to be infected with dwarf mistletoe.

BACKGROUND INFORMATION

DWARF MISTLETOE

IS A FLOWERING, SEED-BEARING PLANT

IS A PARASITE

IS DIOECIOUS AND PERENNIAL

IS INSECT POLLINATED

GROWS BEST IN FULL LIGHT

SHEDS MOST AERIAL SHOOTS UPON MATURITY

ATTACKS TREES OF ALL SIZES AND AGES

IS SPECIFIC TO A HOST TREE OR GROUP OF HOST TREES

REDUCES GROWTH, LOWERS QUALITY

KILLS & PREDISPOSES TO ATTACK BY OTHER PESTS

CHART II

BACKGROUND INFORMATION

1. **Is a flowering, seed bearing plant**—Dwarf mistletoe plants flower in spring or in late summer to early fall, depending upon species. They produce a fruit (berry) containing a single seed and have rootlike parts "endophytic system" imbedded in host tissues.

2. **Is a parasite**—Aerial shoots have some chlorophyll, but plants are primarily parasitic and incapable of meeting their own nutritional requirements. Therefore, they can survive only as parasites on a suitable living coniferous host.

3. **Is dioecious and perennial**—Male and female flowers are produced on separate plants, and only female plants produce berries. Both sexes usually occur on same tree. Infections are perennial and form brooms or swollen cankers. New shoots are continually being produced at infection centers. Endophytic system lives for many years and slowly advances distally and proximally along infected parts.

4. **Is insect pollinated**—Female flowers are polinated by insects. Wind is probably also involved.

5. **Is specific to a host tree or group of host trees**—Douglas-fir and lodgepole pine dwarf mistletoes are specific to their tree hosts with occasional crossovers. Forms in the **campylopodum** complex each have major tree hosts. Crossovers to other tree species are of importance in some areas.

6. **Attacks trees of all sizes and ages**—The size, age, or vigor of a susceptible tree wil not prevent its becoming infected.

7. **Aerial shoots are perennial**. The aerial shoots can persist for several years and bear successive crops of flowers.

8. **Grows best in full light**—Opening up stands may increase production and vigor of aerial parts; full effects of this on spread and intensification are unknown.

9. **Reduces growth and lowers quality**—The tree's photosynthates are used by the parasite, thus reducing the amount of food available to the tree. Growth loss is probably 50% or more in heavily infected trees.

10. **Kills and predisposes to attack by other pests**—A large number of infections or heavy brooming may deprive the tree of nourishment and starve it to death. Weakened trees are susceptible to invasion by fungi or insects. The tree's life expectancy is lower than it would be if non-infected. Brooms and bole cankers may serve as entry points for decay-causing fungi.

LENGTH OF LIFE CYCLE VARIES

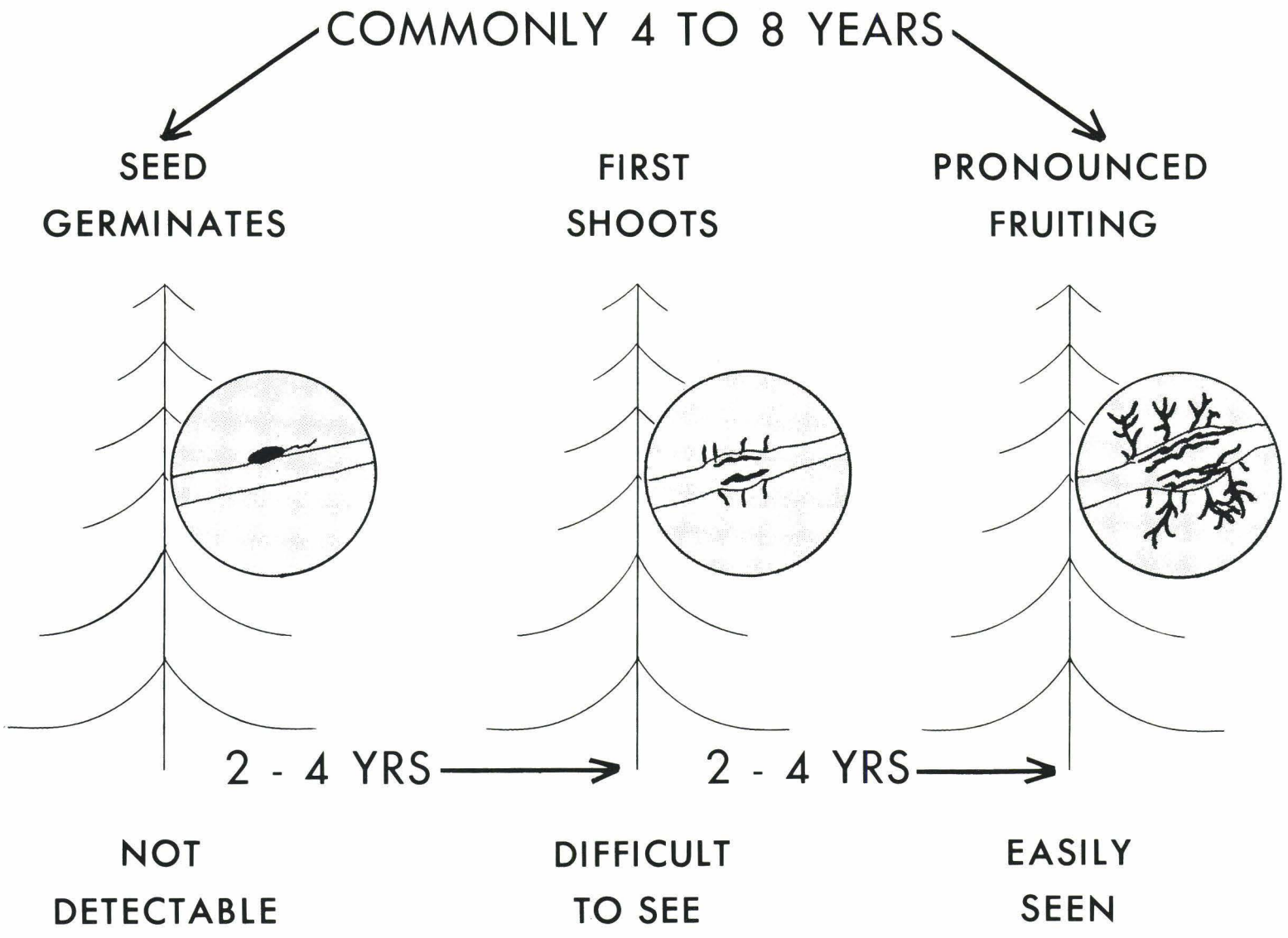


CHART III

LENGTH OF LIFE CYCLE VARIES; COMMONLY 4 TO 8 YEARS

The life cycle of dwarf mistletoe, or period of time from seed to seed, is variable. Variability may occur both between and within species. For several years the parasite develops primarily within the host tissue and is not easily detectable. Generally 4-8 years is the minimum time required for a new infection to develop to the point where some reinfection is possible.

Light conditions and vigor of the host tree probably play a large part in length of the life cycle. The Douglas-fir, lodgepole pine and ponderosa pine dwarf mistletoes are spring-flowering species, producing seed 16 to 18 months after pollination.

1. **Seed germinates. Not detectable.**—Seed dispersed in autumn will germinate and penetrate the following spring or become devitalized. An exception to this is **A. vaginatum** which germinates in the fall. Infection is not detectable at this stage except by close examination.

2. **First shoots. Difficult to see.**—First shoots generally appear 2-4 years after initial infection. Newly emerged shoots are not easily seen, especially in needle-bearing portions of branches.

3. **Pronounced fruiting. Easily seen.**—After an additional 2-4 years, the plants have flowered. Many will reach maturity with the females producing seed. At this stage most infections are easy to detect. Formation of witches'-brooms often has begun. Infections high in the crown of the tree can be seen with the naked eye or with binocular field glasses.

The life cycle given here and on the accompanying chart is greatly simplified. Many differences in details of life cycle occur between dwarf mistletoe species, host trees, and locality. Nevertheless, the life cycle as presented gives enough general background to show the practicing forester how infections may develop.

CROSS SECTION OF DWARF MISTLETOE INFECTED LIMB

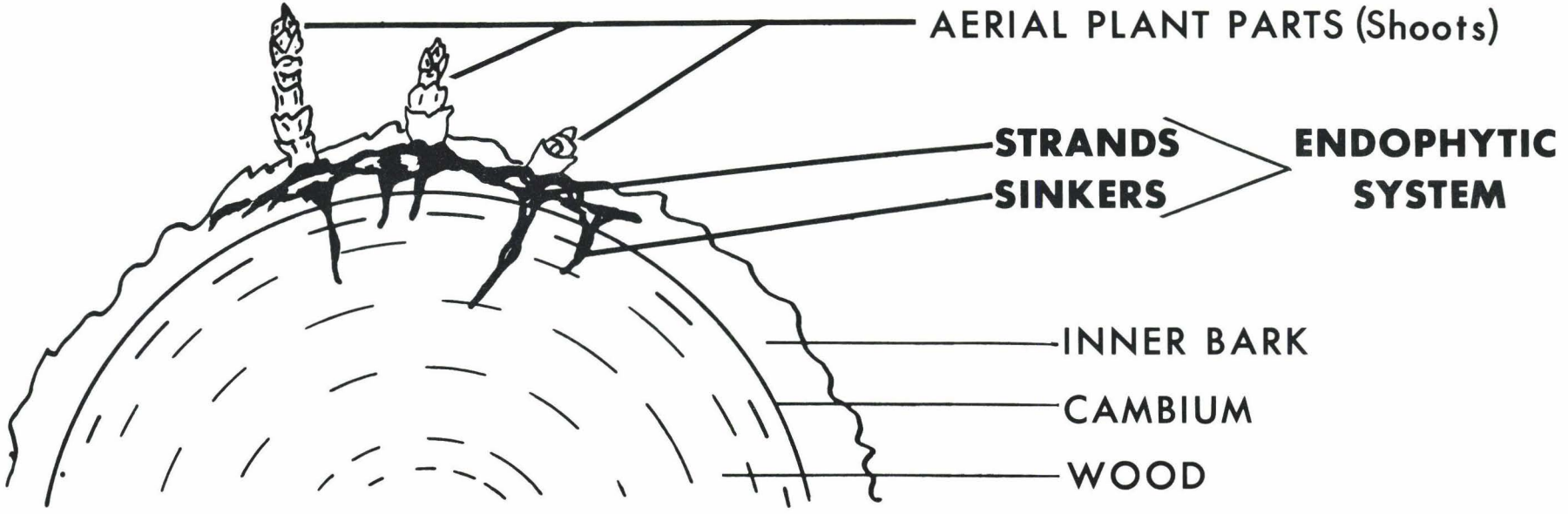


CHART IV

CROSS SECTION OF DWARF MISTLETOE INFECTED LIMB

Aerial Portion of Plant

Shoots may be simple or branched. Size varies by species. **A. douglasii** (Douglas-fir dwarf mistletoe) shoots are frequently simple and generally ¼ to ¾ inch in length. Shoots of **A. vaginatum** are branched and average, 4 to 6 inches in length.

Shoots are always segmented (jointed), and leaves are reduced to opposite pairs of scales at the top of each segment. Color varies from yellowish to olive-green to shades of brown and purple depending upon species, light, temperature, and latitude. After a shoot has been shed the "basal cup" or first segment of the shoot often remains on the bark for many years.

Endophytic System

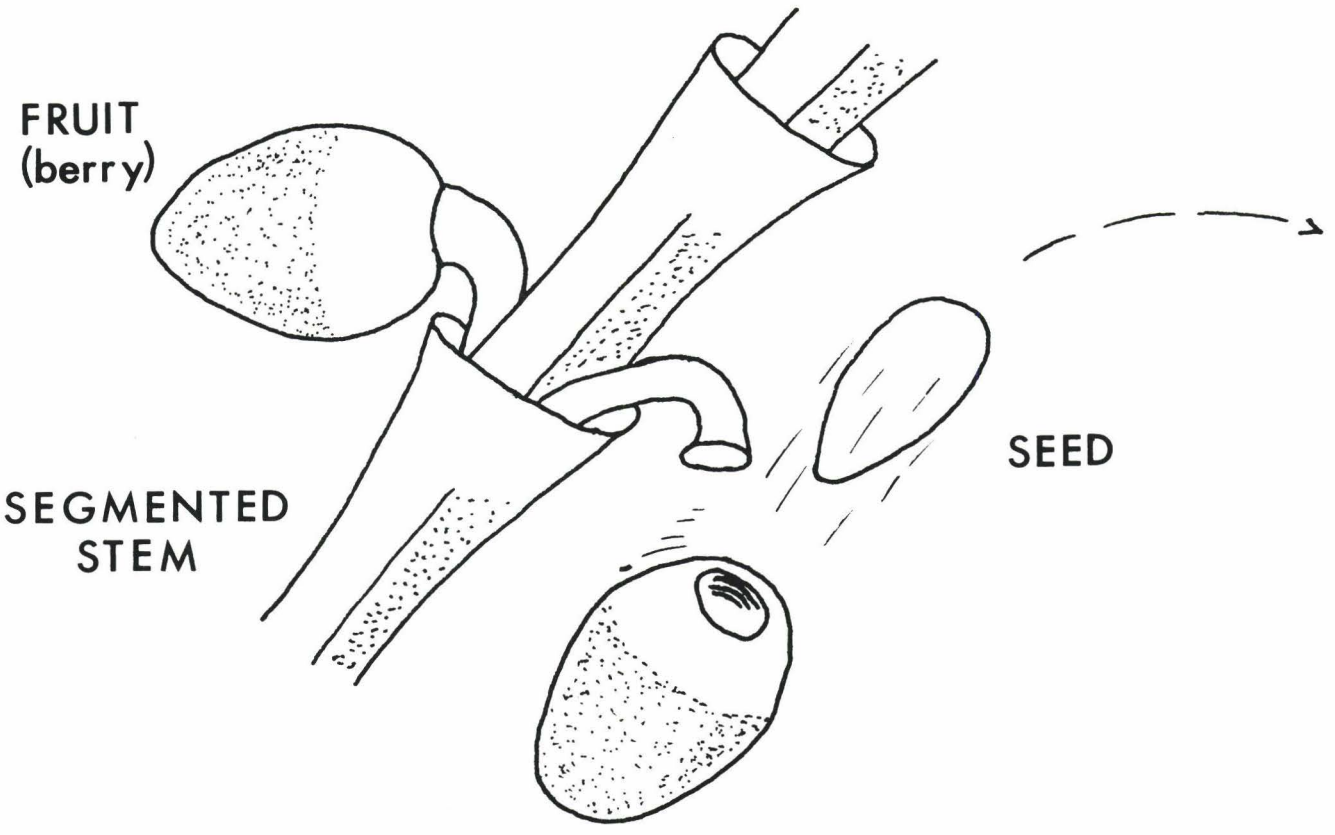
The endophytic system is composed of cortical and sinker systems. The cortical system consists of strands situated throughout the inner bark (phloem) zone of the infected portion of the host branch or stem. This system produces buds which break through bark and emerge as aerial shoots. The cortical system also produces "sinkers" that extend radially through the cambium and become imbedded in the wood.

The presence of strands in the inner bark and sinkers in the wood result in the typical swelling or "swollen cankers" at infection points.

The physiological function of the endophytic system is little understood. Presumably the cortical strands extract some organic substances from the host, but how this may be accomplished is unknown. The sinkers on the other hand develop vascular elements in direct contact with those of the host and thus confirm their presumed function of extracting water and minerals.

The ability of the endophytic system to live and continue its parasitic action without the presence of aerial parts is well known. Therefore infections where bark is too thick for aerial shoots to emerge can still be damaging to the host tree.

DWARF MISTLETOE SPREADS BY EJECTING SEEDS



SPREAD IS FROM:

1. TREE TO TREE
2. BRANCH TO BRANCH WITHIN TREE

CHART V

DWARF MISTLETOE SPREADS BY EJECTING SEEDS

The dwarf mistletoes produce a fruit with an explosive seed-dispersal mechanism that is one of the most efficient in the whole plant kingdom.

Fruit (berry)—The fruit is an ovoid berrylike structure borne on a short stem and about the size of a grain of wheat. In the west, berries of the various dwarf mistletoes reach maturity and release seeds in the fall, generally in August and September.

Seed—Each fruit contains a single, tear-shaped seed 2 to 3 mm long. The seed is a naked embryo and endosperm encased in the berry. It is surrounded by viscin cells that produce viscin, a sticky-gelatinous substance responsible for the buildup of pressure to eject the seed and for the seed's adherence to whatever it lands upon.

Dispersal mechanism—As the berry approaches maturity its stem is elongated and recurved so that the top of the berry points downward. An abscission zone then develops between the tip of the stem and base of the berry. The viscin cells between the seed and the berry's hull absorb water, creating a high internal pressure. Finally, the fruit falls from the stem, the hull contracts rapidly, and the seed is ejected upward and outward. Its bullet shape makes the seed a most efficient projectile.

The seed's initial velocity as it leaves the fruit has been measured at 80 to 90 feet per second, or about 60 miles per hour!

With this seed-dispersal mechanism, dwarf mistletoe spreads from tree to tree and to uninfected parts of the same tree. Infection in a tree is further intensified as established infections become larger.

Dr. Frank Hawksworth, Rocky Mountain Station, is studying the dispersal, interception, and movement of seeds of both the lodgepole pine and ponderosa pine dwarf mistletoes in southwest United States.

Dr. Lewis Roth, Oregon State University, is studying the fertility, production, and dissemination of ponderosa pine dwarf mistletoe seeds in eastern Oregon. His findings will relate to damage forecasting and silvicultural control.

APPROXIMATE DISTANCE & RATE OF SPREAD

FASTEST SPREAD FROM RESIDUAL OVERSTORY TO UNDERSTORY

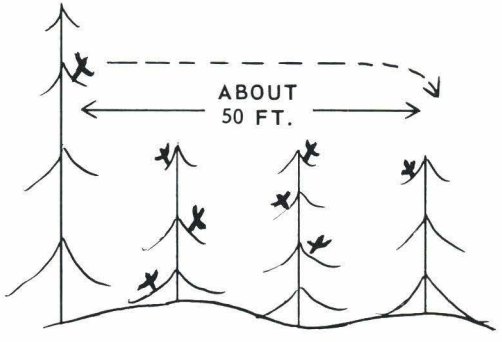
LATERAL SPREAD THROUGH YOUNG ONE-STORY STAND IS SLOW

SEED DISPERSAL:

80% WITHIN 30 FT.

95% WITHIN 50 FT.

5% OVER 50 FT.



1.5 FEET PER YEAR OR MORE

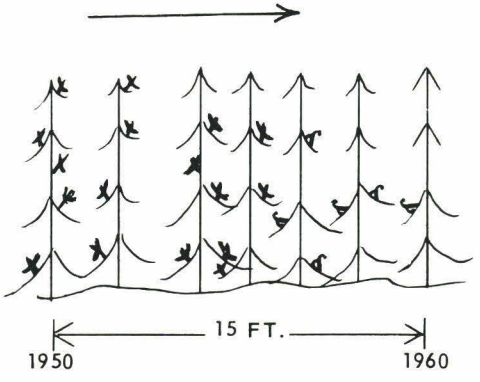


CHART VI

APPROXIMATE DISTANCE AND RATE OF SPREAD

Local spread of dwarf mistletoe is by seeds that rarely travel far. In long-distance spread beyond the effective range of the explosive fruits, birds are suspected. Wind may also influence distance of spread, although its importance varies greatly with species, locality, and type of stand.

The type of stand influences the rate of spread. Spread is most rapid from overstory trees to understory, while spread through even-aged stands is relatively slow. In general, spread is faster through open stands than through dense ones. However, if the distance between trees exceeds the distance of seed flight, spread is limited.

In a two-storied stand, the understory within range of an overstory infection source can become infected in a few years. Often the results are rapid and severe intensification of infection occurs over time. Although distance and rate of spread varies by species of dwarf mistletoe and local conditions, a protection zone of 50 feet will suffice in most instances. Estimates are that about 80 percent of the seeds land within 30 feet of the source plant, an additional 15 percent within 50 feet, and 5 percent or less beyond 50 feet.

Initially all infections in the young stand develop directly from seed produced in nearby overstory trees. Then a transition period occurs when infections in the young stand produce seeds that further infect the stand. Subsequently, infection progresses in the young stand outward beyond the range of seeds produced in the overstory stand.

Beyond the limits of the overstory "barrage," spread through an even-aged stand is slow but consistently progressive. Measurements made in 33 lodgepole pine stands in Colorado and Wyoming showed the rate of lateral spread was 1 to 1.5 feet per year. Comparable studies on ponderosa pine mistletoe indicate that this spread is slightly greater.

REQUIREMENTS FOR INITIAL DWARF MISTLETOE INFECTION

MUST HAVE SUCCESSFUL:

1. SEED PRODUCTION
2. SEED LIBERATION
3. SEED TRANSPORT
4. SEED DEPOSITION
5. SEED GERMINATION
6. PENETRATION & ESTABLISHMENT OF RADICLE
7. GROWTH & SURVIVAL

CHART VII

REQUIREMENTS FOR INITIAL DWARF MISTLETOE INFECTION

Upon maturity dwarf mistletoe seeds are scattered in all directions from infected trees. They land everywhere—on various parts of trees, on understory vegetation, and on the ground. Probably fewer than half of the seeds produced lodge on trees, and fewer than 5 percent of those actually take root.

The ones that do result in infection, however, are usually those landing on needles. A viscous, adhesive coating enables them to stick where they land. When moistened by rains, the coating lubricates the seeds so that they can slide down to the twigs.

Germination usually must occur at or near young twigs to produce infections on the host. Most infection takes place on growth less than 5 years old. Many seeds fall from the needles or fail to slide down and are lost, but enough reach the twig to maintain parasitic populations.

For a new infection to take place the seeds must go through seven major steps. Roadblocks may occur at any one of the steps and prevent successful establishment of a new infection. **First**, viable seed must be produced; **second**, this seed must be successfully liberated; **third**, successfully transported; **fourth**, successfully deposited on young growth of a susceptible tree; **fifth**, the deposited seed must germinate and; **sixth**, its radicle (rootlet) must successfully penetrate and become established in the host tissue. **Finally**, the newly established infection must continue to grow and survive.

Some studies indicate that initial dwarf mistletoe infections can be quite cyclic; in certain years a number of new infections become established; in other years very few get started. Several factors may limit infections in any one year. Climatic conditions can be detrimental to seed production, germination, or survival. Seed production can be limited by fungi or insects that parasitize the dwarf mistletoe flowers, shoots, or fruit. Regardless of the number of poor infection years, good years occur in most stands at frequent enough intervals to cause considerable new infections.

Research studies are now underway on the population dynamics of dwarf mistletoe in ponderosa and lodgepole pines. Results will give us better information to evaluate the damage potential in stands based on predictable mistletoe population trends.

AVERAGE MERCHANTABLE VOLUME (CU. FT.) FOR LODGEPOLE PINE AT THREE AGE CLASSES

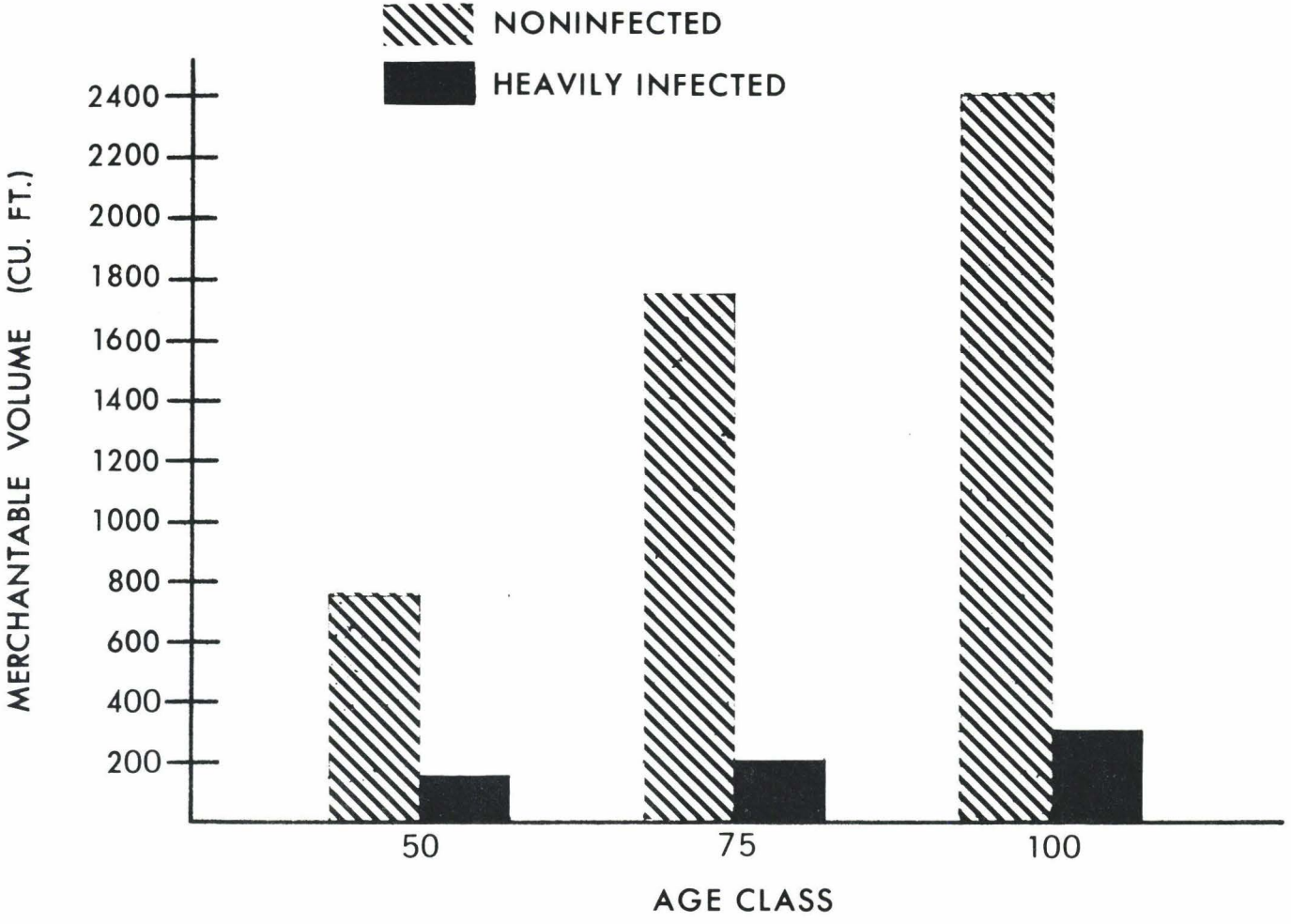


CHART VIII

GROWTH IMPACT

The greatest impact of dwarf mistletoe infection is on growth. In addition to reduced increment, infection causes increased mortality, lower timber quality, and indirect losses.

Infected trees grow at a slower rate than healthy ones. However, effect on growth is usually insignificant until the tree is moderately infected. In general growth is less in trees with multiple witches' -brooms than in infected trees without multiple brooming. Both diameter and height growth are affected. Recent studies indicate that in heavily infected trees impact on height growth is about 25% greater than on diameter growth; in moderately infected trees, about 50% greater. A total increment loss of 1/3 in some host species to over 2/3 in others may occur in heavily infected stands.

The accompanying chart presents the average merchantable cubic foot volume for lodgepole pine at three age classes. Values were obtained from a 1964 study by Hawksworth and Hinds at the Rocky Mountain Forest and Range Experiment Station.

Hawksworth studied effects of dwarf mistletoe on diameter increment of ponderosa pine in the Southwest. In a 55-year-old pole stand radial increment of heavily infected (class 6) trees for the 5-year period previous to measurement was 35% less than the healthy and lightly infected trees. Infection with brooming produced greater reductions in diameter and height growth than comparable infection without brooming.

The effects of dwarf mistletoe on basal area growth of southwestern ponderosa pine was studied by Lightle at the Rocky Mountain Station. During a ten-year period the heavily infected trees (class 6) averaged a minus 0.80 square foot of basal area growth per tree. This negative growth was due to increased mortality.

Shea investigated effects of dwarf mistletoe infection on diameter growth of 32 old-growth Douglas-fir trees near Klamath Falls. During the past 10 decades, average d.b.h. increment of trees with moderate and severe infection was 79 and 43% respectively of that in otherwise similar but lightly infected trees. In Region 2 mortality is often severe.

DWARF MISTLETOE CONTROL PRINCIPLES

PREVENTION IN REGENERATION AREAS

REPLACE INFECTED STANDS WITH CLEAN STANDS

PROTECTION OF CLEAN OR LIGHTLY INFECTED STANDS

REDUCE CONTINUOUS INTENSIFICATION IN YOUNG STANDS BY REMOVAL OF INFECTED OVERSTORY

RESTRICT SPREAD FROM ADJACENT INFECTED STANDS

SUPPRESSION IN THRIFTY YOUNG STANDS

REMOVE ANY INFECTED OVERSTORY

SANITIZE INFECTED AREAS

RESTRICT SPREAD AND INTENSIFICATION

CHART IX

DWARF MISTLETOE CONTROL PRINCIPLES

First priority in dwarf mistletoe control involves prevention and protection measures. We must prevent newly regenerated and dwarf mistletoe-free stands from becoming infected. Restricting spread from infected areas into contiguous uninfected areas has high priority. Preventing existing infected stands from becoming more heavily infected is an important part of the control job.

Second priority in dwarf mistletoe control is to suppress the infection in thrifty young stands by local sanitation—that is, by removing infected trees or parts of trees along with precommercial thinning.

Control is now economically feasible only where thinning is practical, unless the stand is lightly infected and sparsely stocked. In overstocked stands, sanitation should always be accompanied by thinning, since (1) growth will be insufficient to yield an adequate return on the sanitation investment, and (2) the two operations will cost less in combination than separately. Conversely, thinning infected stands should also include sanitation. Dwarf mistletoe, if uncontrolled, will greatly reduce returns from the thinning investment.

Harvesting of mature and overmature dwarf mistletoe infected stands has top priority in cutting practices in Region 2. This priority is very important not only to recover deteriorating timber but it is often a necessary step preparatory to prevention, protection, or suppression practices.

PLANNING FOR CONTROL

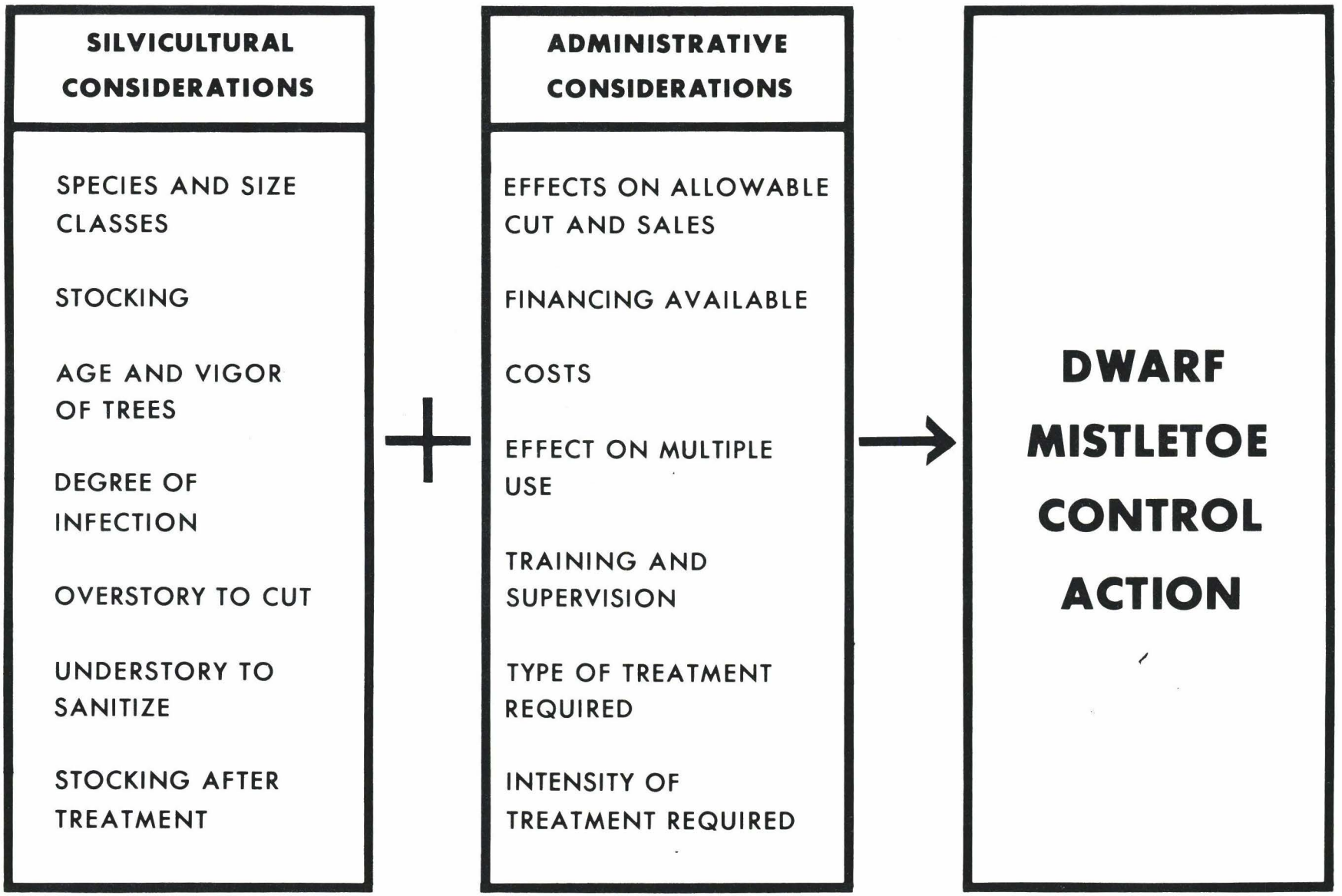


CHART X

PLANNING FOR CONTROL

This chart outlines the factors that must be considered before the forester is ready for dwarf mistletoe control action. A number of silvicultural (or biological) and administrative considerations must be evaluated. Timing and scheduling of these events are involved in all phases of timber management from presale planning to post-sale stand improvement.

The correct decision for control may have a major effect on the overall timber management program and on the future productivity of and return from the treated stand. Therefore, control will be given consideration in all infected stands, but will be undertaken only in units where the stand will benefit substantially.

Planning for dwarf mistletoe control must take into consideration procedures that give adequate control. Procedures must be consistent with good fire control, watershed, and wildlife practices, must protect recreational values, and must consider appropriate silvicultural systems and regeneration needs. In lightly infected stands satisfactory control can be attained with little or no departure from currently accepted management principles. In severely diseased stands where control is warranted, little will be accomplished unless some of the normal practices are modified.

SUPPRESSION PRIORITIES

FIRST	SECOND
SEEDLINGS, SAPLINGS	POLES
LIGHT INFECTION	HEAVY INFECTION
SMALL CENTER	LARGE CENTER
HIGHLY PRODUCTIVE SITE	MODERATELY PRODUCTIVE SITE

CHART XI

SUPPRESSION PRIORITIES

In seedling and sapling stands, control is easier and less expensive and benefits are greater than in pole stands. Suppression measures ordinarily should not be performed in pole-sized stands unless the trees are large enough and markets are available for a commercial thinning. Unless infection is extremely light, sanitation in pole stands will result in serious reduction of stocking and sacrifice of accumulated growth. Also, thorough sanitation is difficult to attain because the larger and older the tree, the more likely it is to bear latent or overlooked infections.

Suppression is probably more profitable in lightly infected stands than in heavily infected ones. Total costs are lower and chances of a thorough sanitation are better than where infection is heavy. Lightly infected stands almost always include enough uninfected trees well enough distributed to provide adequate stocking after sanitation. Many leave trees will be crop trees or potential crop trees; the opposite is true in heavily infected stands.

Expenditures now made for control in suitable stands will increase yields from the present rotation and reduce the size of later control jobs. This is true in large infection centers as well as small ones. Nevertheless, if per acre expenditures for control in small centers are about equal to those in large centers, benefits derived will probably be greater in the former instance than in the latter. Where small infection centers occur in a large uninfected area, thorough sanitation provides control in the infected center and protects the surrounding stand.

Timber stand improvement priorities in Region 2 state that effort will be concentrated on the better sites. Because mistletoe suppression practices are an intregal part of other management practices, the same priorities apply.

DWARF MISTLETOE SURVEYS

SCOUTING SURVEYS

- INVOLVE AERIAL OR GROUND DETECTION
- DETERMINE
  - OCCURRENCE
  - DISTRIBUTION
  - PREVALENCE
  - NEED FOR OPERATIONAL SURVEY

OPERATIONAL SURVEYS

- INVOLVE A SYSTEMATIC SAMPLE
- YIELD QUANTITATIVE DATA
- PROVIDE DETAILS FOR PLANNING AND PRACTICING EFFECTIVE CONTROL

CHART XII

DWARF MISTLETOE SURVEYS

Dwarf mistletoe surveys are needed to program an orderly harvest in infected merchantable stands and to plan silvicultural control in any infected stand regardless of tree species or age. They may be made to determine distribution, prevalence, and damage—where it is found, where it is causing serious damage, when and where it is intensifying; or to determine when, where, and how control is feasible, and the economic and biological needs for control.

Surveys should tell where control can be successfully applied now, and where control should be delayed because it will not pay at the present time. Threatened or future damage as well as a measure of current losses should be considered in any damage appraisal.

Surveys for dwarf mistletoe are of two types—scouting and operational. Ordinarily, a scouting survey should be made first, followed by an operational survey. The principal differences between the two surveys are in the intensity of coverage and in the detail or kind of information taken.

Surveys made in ponderosa pine stands in the late 1950's by Experiment Station pathologists show infestations vary from less than an acre to more than 1,000 acres in extent. They are often of irregular shape and tend to occur in groups rather than at random. Intervening uninfected zones vary from a few yards up to many miles in width.

In ponderosa pine stands, survey information for dwarf mistletoe control frequently has been collected as an integrated part of presale plans; sale layout, cruising, marking, etc. This has worked well in most instances. Whenever suitable, it is encouraged in lieu of more formalized, independent surveys.

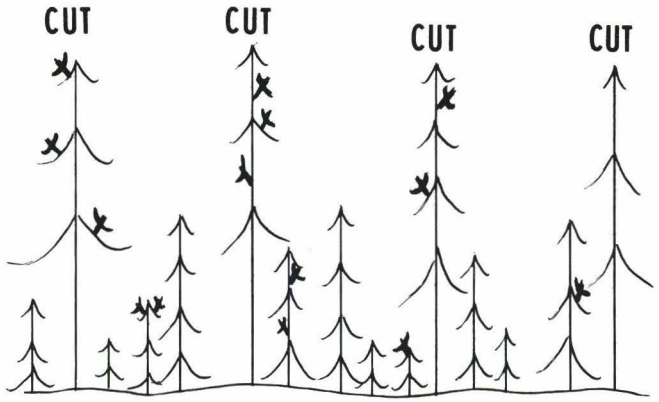
Dwarf mistletoe surveys which will do nothing but tell us more of what we already know should never be made.

Contact the Branch of Pest Control in Denver for details on surveys.

GENERAL APPROACH TO CONTROL

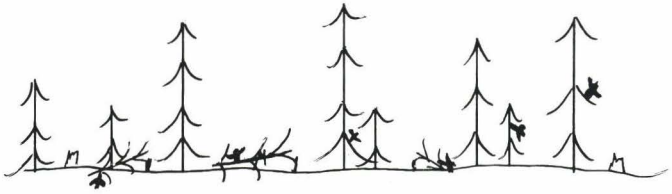
FIRST STEP

REMOVE ALL
INFECTED OVERSTORY



SECOND STEP

THIN AND
SANITIZE UNDERSTORY



THIRD STEP

FOLLOW UP AS NEEDED
IN THREE TO FIVE YEARS

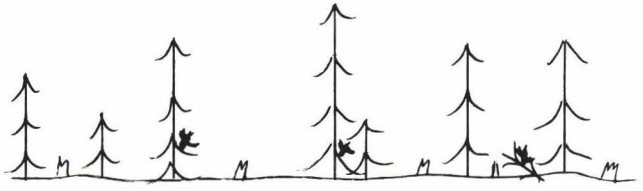


CHART XIII

GENERAL APPROACH TO CONTROL

Dwarf mistletoe can be controlled by silvicultural means. Silvicultural control is achieved by removing infected trees or limbs to sanitize the stand and to inhibit or reduce the distribution of dwarf mistletoe seed. Thorough sanitation is the aim. Alternatives that give a lesser degree of control should be avoided, and cutting practices or other stand treatments that accelerate dwarf mistletoe development and damage must be avoided.

For most effective control, the general approach is:

1. **Remove all infected overstory trees.** The infected overstory must be removed before sanitation can be started in the understory or before regeneration is accomplished. Generally this means complete overstory removal, both merchantable and nonmerchantable trees. Avoid cutting overstory trees during the parasite's seed dispersal period to prevent undue spread.

2. **Thin and sanitize understory.** With few exceptions dwarf mistletoe sanitation in young stands is done in connection with precommercial thinning. Felling infected trees has priority over pathological pruning. Pruning to sanitize individual trees will be avoided except where necessary to maintain an adequate number or quality of leave trees. Delaying original sanitation in trees under 12 years old for 3 to 5 years after overstory removal will give new and latent infections time to become visible. In trees older than this secondary infection (infection from young tree to young tree as opposed to primary infection which is infection from overstory to young trees) is taking place. In these trees the original sanitation should accompany overstory removal.

3. **Follow up as needed.** Follow up sanitation 3 to 5 years after the original work will be needed in most stands to reduce dwarf mistletoe incidence to an innocuous level.

   Complete eradication of the parasite from any given area is difficult and costly. As stated previously, sanitation must be thorough but complete eradication is not practical. Some infected trees can be left provided the tree is needed for stocking and is otherwise a desirable tree—if the infection is light, occurs below the general mid-crown level of the stand being treated, and is not a threat to spread and intensification in surrounding trees of a lower height level.

OVERSTORY REMOVAL CONSIDERATIONS

INFECTED OVERSTORY WITH ESTABLISHED YOUNG UNDERSTORY

ALTERNATIVES

1. REMOVE ENTIRE OVERSTORY; THIN AND SANITIZE UNDERSTORY.

2. IF UNDERSTORY IS HEAVILY INFESTED CONSIDER ALTERNATIVE 2 ON THE RIGHT SIDE OF THIS CHART.

INFECTED OVERSTORY WITHOUT AN ADEQUATE UNDERSTORY

ALTERNATIVES

1. MAKE **REGENERATION** CUT TO ESTABLISH REPRODUCTION; MAKE FINAL CUT WITHIN 5 YEARS OF ESTABLISHMENT OF ADEQUATE REPRODUCTION.

2. REMOVE OVERSTORY IN ONE CUT, DESTROY ADVANCED REPRODUCTION, AND REGENERATE.

CHART XIV

OVERSTORY REMOVAL CONSIDERATIONS

General overstory removal guides are given in the accompanying chart. Before deciding upon overstory removal an analysis of growing stock is needed. If an understory is present the infection intensity, stocking conditions, and thrift of understory are important considerations in deciding time and method of overstory removal. If an understory is absent or not worth saving, plans to regenerate the site to a new stand of uninfected trees must be made.

Remember that it is generally best to remove all overstory trees without exception. In an infected stand most overstory trees will have some infection and even those that are growing well may not contribute enough volume to compensate for the infection they will spread to the young stand. Some exceptions to complete overstory removal are:

1. The overstory tree is of a species other than that under attack by dwarf mistletoe.

2. You are certain that the tree is not infected.

3. There is no growing stock of the host species within 50 feet of the overstory tree.

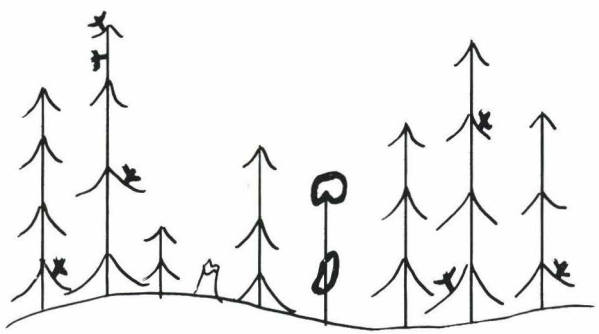
4. Growing stock consists of pole or young mature sawlog-sized trees and no thorough sanitation is contemplated.

5. A seed-tree or shelterwood cut is planned. In this instance the overstory should be removed within 5 years after reproduction is established. Reproduction should then be sanitized after a lapse of 3 to 5 years.

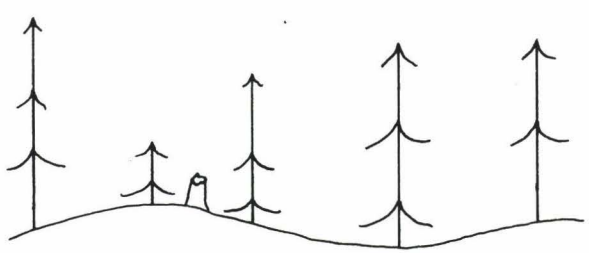
Some control is achieved by removing an infected overstory whether or not the understory qualifies for treatment. The longer the growing stock is subjected to a barrage of dwarf mistletoe seeds from above the greater infection intensity will become. Therefore, removing infected mature trees over saplings, poles, or young mature trees accomplishes some degree of control whether or not sanitation is undertaken in the understory.

TREAT SAPLING STANDS;
AVOID SANITATION IN POLE STANDS

REPRODUCTION OR SAPLING STAND
MAJORITY OF STEMS UNDER
5 INCHES

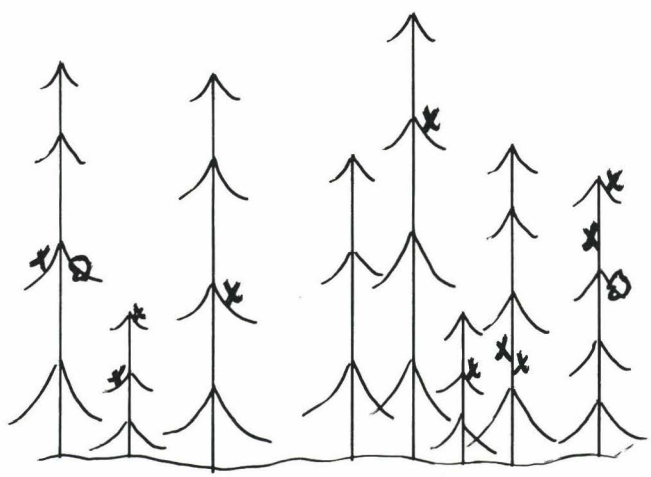


BEFORE



AFTER

POLE STAND—½ ACRE OR MORE
MAJORITY OF VOLUME IN
STEMS OVER 5 INCHES



DELAY CONTROL UNTIL
MERCHANTABLE
PRODUCT

CHART XV

TREAT SAPLING STANDS: AVOID SANITATION IN POLE STANDS

Although there are exceptions, opportunities for dwarf mistletoe sanitation are best, both from pathological and economical standpoints, in sapling-sized stands.

Sapling stands offer better control opportunities than do pole stands because (1) early thinning shortens the rotation, (2) examining trees for infections is less expensive, (3) sacrifice of accumulated growth is held to a minimum, (4) a high level of stocking can be maintained, (5) greater freedom of choice in crop tree selection permits better spacing of better trees, (6) chances for thorough sanitation are greater, and (7) less slash is created.

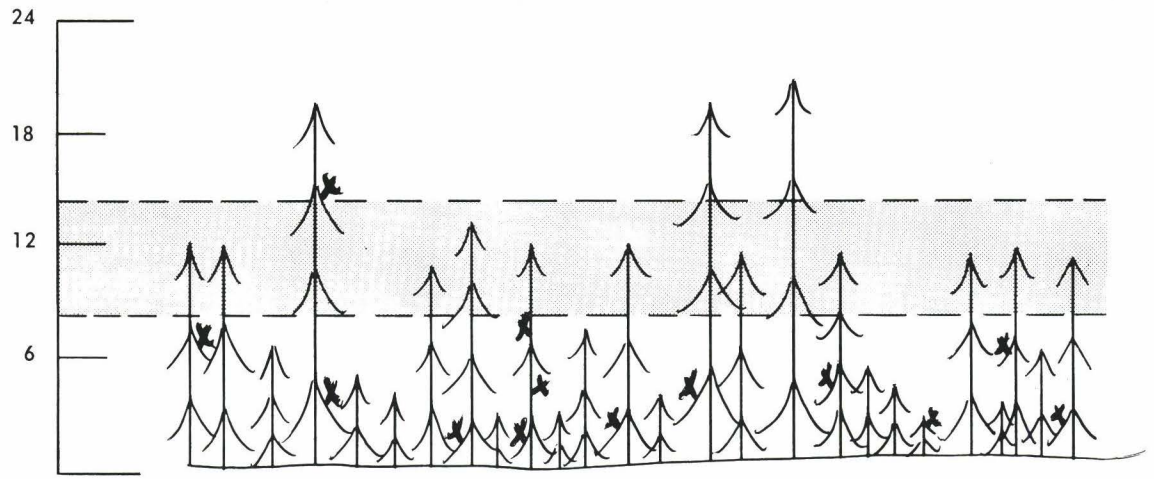
The larger the reproduction the more abundant the infection. Larger trees present more crown to intercept dwarf mistletoe seeds, are less often screened from sources of infection by intervening trees, have a greater area of susceptible new growth, and have usually been exposed for more years.

Sapling stands, unless exceptionally sparse or heavily infected, tend to include enough well distributed uninfected trees to provide at least fair stocking after sanitation. Although uninfected trees in sapling stands average smaller than their infected neighbors, most of them, unless badly suppressed, will grow well when released.

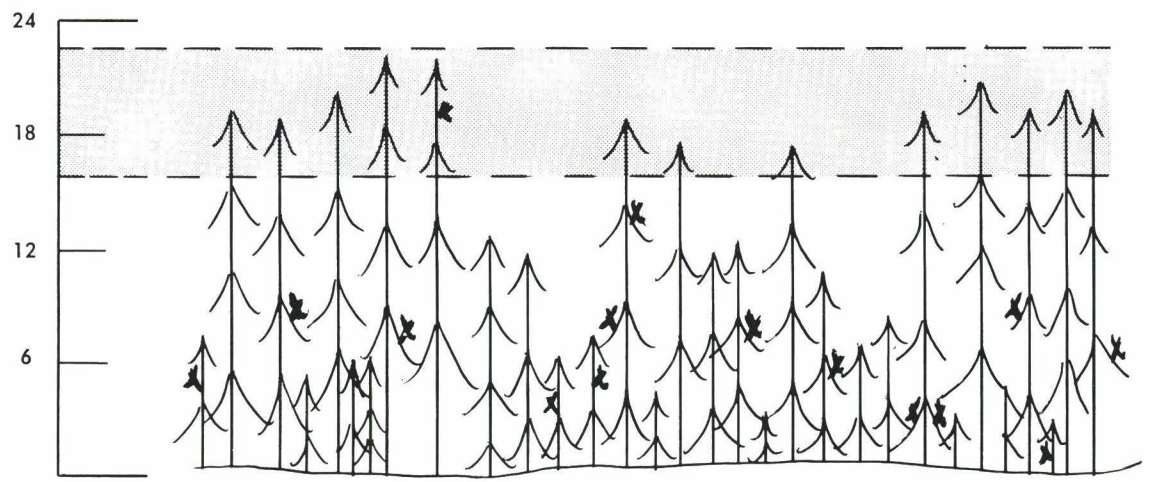
Control in pole stands is often impractical because of high direct costs and also because of the high indirect cost—that is, the sacrifice of potential volume. Such stands, if only moderately infected and growing reasonably well, can be expected to yield some commercial volume within a few years without sanitation. In such stands it is best to delay control until merchantable material can be harvested. As a general guide, centers of pole-sized trees 1/2 acre or more falling within a sapling stand should be deleted from sanitation measures; conversely, pole patches of less than about 1/2 acre should be treated the same as the surrounding saplings.

In some instances, however, control in pole stands should be considered. (1) If infection is severe in pole-sized stands (especially small poles), the commercial crop will be negligible. Here sacrifice of stocking or accumulated growth may be practical if control costs are less than the value of the crop expected after control. (2) If small infection centers of poles occur in a sapling stand that is otherwise uninfected, control in the center is justified because the surrounding stand will be protected. (3) Control in pole stands can be considered where saplings are common and infection is light enough to permit sanitation without excessive sacrifice of the pole-sized trees.

TREATMENT IN AN UNDERSTORY THAT CONSISTS OF MULTIPLE HEIGHT LEVELS



SELECT 8'-14' HEIGHT LEVEL



SELECT 16'-22' HEIGHT LEVEL

SELECT THE HIGHEST HEIGHT LEVEL THAT PROMISES TO PROVIDE AN ESSENTIALLY SINGLE STORIED STAND OF SATISFACTORY STOCKING IN THE NEXT ROTATION; CONCENTRATE SANITATION IN THIS TREE HEIGHT CLASS.

CHART XVI

TREATMENT IN AN UNDERSTORY THAT CONSISTS OF MULTIPLE HEIGHT LEVELS

Some of our infected young stands consist of multiple height classes rather than uniform height levels. The understory may contain reproduction, saplings, and small or large poles all intermingled or in small groups.

Multi-storied stands of young growth having no distinct single height level need special consideration in a sanitation-thinning operation to control the parasite. The forest manager should select the height level where control will be concentrated rather than try to control dwarf mistletoe in all size classes. Choice should be based on the height level that will provide the greatest yield from a silvicultural and economic standpoint. Usually it will be the height level that contains the greatest portion of the total basal area.

In the example illustrated at the top of the chart, the forest manager would select the middle or 8- to 14-foot height level to concentrate control efforts.

Sanitation at this level would be thorough. In the lower height level he would thin and discriminate against dwarf mistletoe but with no attempt to achieve thorough sanitation. In the scattered larger trees above the 8- to 14-foot level sanitation should be thorough to prevent spread to trees below.

In the example at the bottom of the chart, the forest manager would select the upper or 16- to 22-foot height level for thorough sanitation. The middle and lower height levels would be thinned; dwarf mistletoe sanitation would not be ignored, but thorough control would not be required.

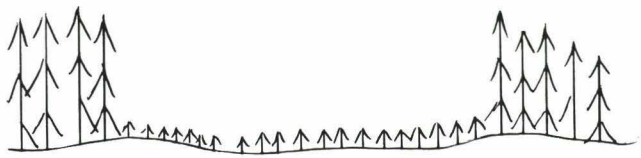
These suggested guidelines do not necessarily imply that a single height level should be selected in an infected stand at large. In fact, it will frequently be desirable to stratify the gross control unit into two or more reproduction groups, each having a different height level where control will be concentrated.

With the exception of some ponderosa pine stands, this treatment is generally not applicable in Region 2.

PROCEDURES IN TREATING CONIFEROUS BRUSH

VERY HEAVILY INFECTED
SPOT OF REPRODUCTION

STAND AFTER
TREATMENT



TREATMENT

1. DESTROY ALL STEMS IN HEAVILY INFECTED SPOTS.
2. REGENERATE AND SANITIZE SURROUNDING STAND.

CHART XVII

PROCEDURES IN TREATING CONIFEROUS BRUSH

When a center in a young stand is so severely infected that the trees are nothing but "coniferous brush," a thorough sanitation treatment will result in inadequate stocking of poor quality trees. Chances for a commercial crop are negligible. In such instances, complete removal of the existing stand and consequent regeneration may be the most practical control method.

Of course, in control action of this type, it is necessary to protect the new regeneration from infection. This can be accomplished by a thorough sanitation for a short distance into the surrounding stand plus followup work in 3 to 5 years.

After destroying the heavily infected center, planting it to a tree species not susceptible to the local dwarf mistletoe is an alternative. Also, if the infection center being destroyed is large, the periphery of the center may be planted to a non-susceptible tree species.

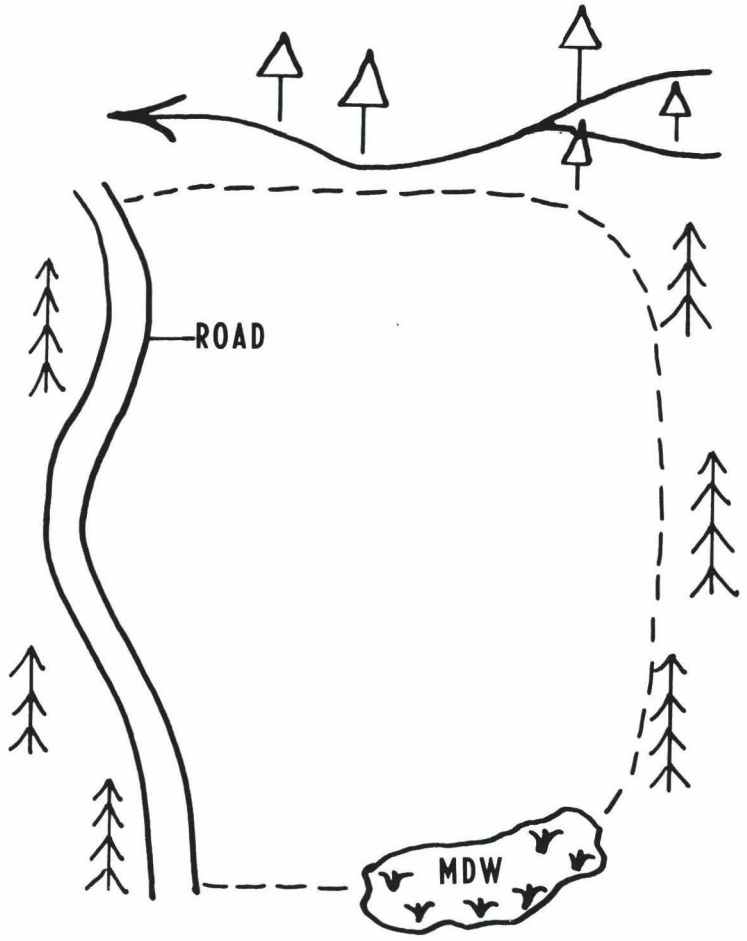
If an overstory is present and the existing understory is to be "wiped out," establishment of regeneration by shelterwood or seed tree cutting may have some merit. The important point to remember is the remaining overstory must be removed as soon as new regeneration is adequate.

Such drastic treatment as destroying the young infected growing stock and starting over may seem too severe. However, if productivity will be almost nil it is a practical procedure. Large areas do not qualify for destruction. Extensive stands of "coniferous brush" are rare. Generally they are small spots of one-quarter to 2 or 3 acres within a stand that otherwise qualify for sanitation of the existing stand.

We have not yet established minimum stocking levels to determine whether a heavily infected spot should be destroyed or saved by thinning and sanitation.

TAKE ADVANTAGE OF EXISTING OPPORTUNITIES

NATURAL BARRIERS



SPECIES MANIPULATION IN MIXED STANDS

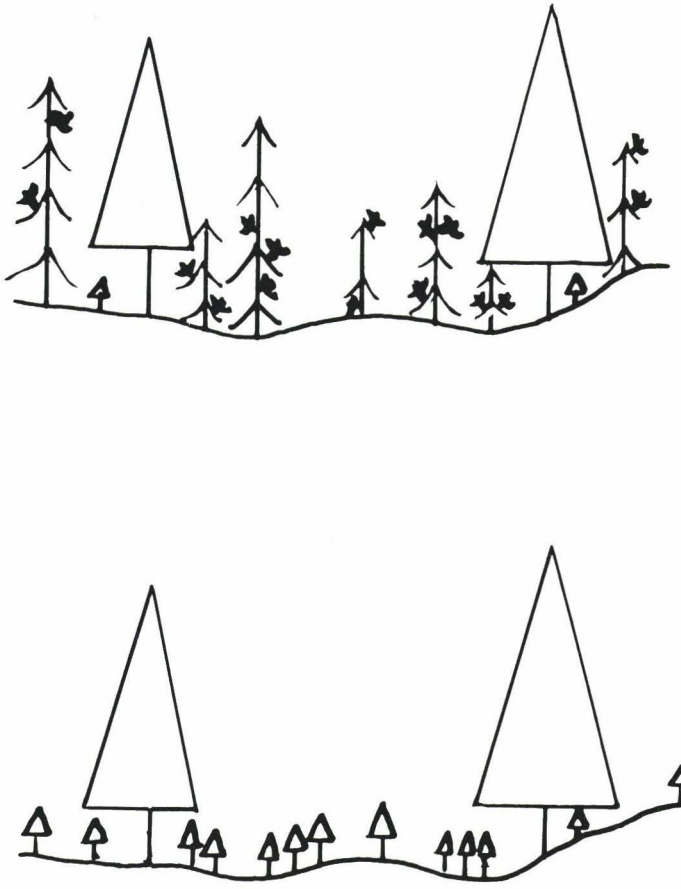


CHART XVIII

TAKE ADVANTAGE OF EXISTING OPPORTUNITIES

Much can be done to prevent spread or invasion of the parasite into new regenerated stands or into sanitized stands by carefully selecting the boundaries of control areas. Natural clearings, such as meadows, lakes, or streams often serve as good control unit boundaries. Ridge crests, rock outcrops, wide roads, or other cleared rights-of-way may also serve. A control boundary should not be established a few feet or chains short of a barrier that would prevent or retard invasion.

Examples of poor boundaries would be those adjacent to infected old-growth of the same tree species being treated or one that passes through a heavy infection center. Control operations in an infected border stand should be scheduled within 10 years and preferably within 5. During this interim period consideration should be given to maintaining a buffer zone between the untreated stand and the control unit.

Trees of one species, even when heavily infected, seldom spread damaging infection to another tree species. Therefore one tree species can be used as a physical barrier to impede spread to another. Extensive areas of continuous dwarf mistletoe infection are rare. Infected areas tend to be scattered with intervening uninfected zones. Whenever possible a control unit should include the entire infected area. The best boundary is one between infected and noninfected areas.

Manipulation of tree species as a control alternative is sometimes possible because the dwarf mistletoes are mostly host specific. Stand manipulation is best suited to mixed stands having commercial tree species that are not susceptible to the dwarf mistletoe present in the area. The nonsusceptible species should be equal or nearly equal in productivity and value to the host species.

Control by species manipulation is accomplished by designing harvest cuttings so that the area will become naturally regenerated or be artificially regenerated with one or more tree species not susceptible to the dwarf mistletoe present. In mixed stands of young growth, control is accomplished by favoring the nonsusceptible tree species during thinning-sanitation operations following overstory removal.

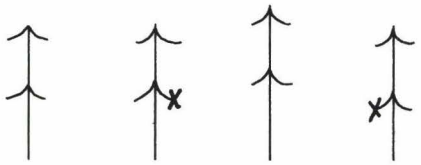
Opportunity for control by species manipulation is sometimes available in pure stands. Pure stands of an infected species may be converted by planting the area to a tree species that is adapted to the site and is not susceptible to the local dwarf mistletoe.

In addition to commercial timber stands, opportunities for control by species manipulation in recreation and special use areas have considerable merit.

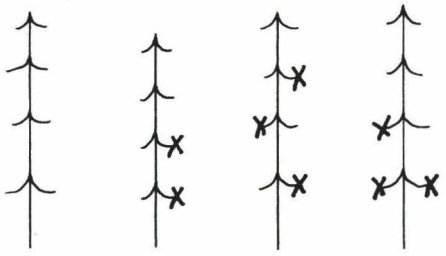
CAN CONTROL BE ACHIEVED WITHOUT COMPLETE SANITATION

ASSUMPTIONS:

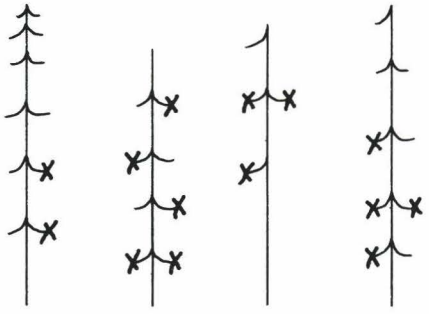
NO OVERSTORY SOURCE OF INFECTION



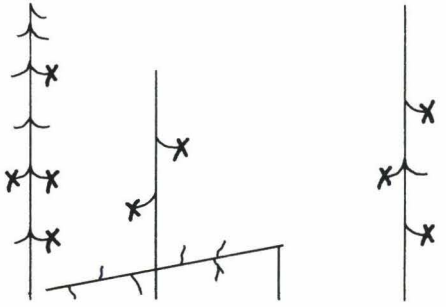
TODAY



20 YEARS



40 YEARS



60 YEARS

CHART XIX

CAN CONTROL BE ACHIEVED WITHOUT COMPLETE SANITATION

In special influence zones or in stands ready for commercial thinning, complete elimination of dwarf mistletoe is impractical. Complete destruction of an existing stand would be incompatible with management goals and sanitation to the degree of complete elimination of the parasite is too expensive to be practical.

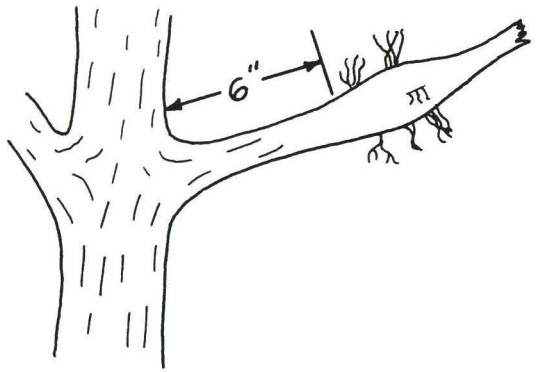
Based largely on observations of control projects and some on scientific evidence, complete sanitation is not necessary. But infection must be reduced and kept to a low level for satisfactory control.

Effectiveness of a sanitation-thinning operation may depend as much on the thinning as on the sanitation. Trees with adequate growing space on fair to good sites and light infection restricted to the lower crown may be able to keep ahead of the upward progress of dwarf mistletoe long enough to produce a good yield of commercial material.

Keeping infection at a low level is strongly dependent on the cutting cycle. A tree that is classed as "light infection" will probably grow for another 10 to 20 years but not for 40 years and could be dead in 50 to 60 years. This means that, depending on the expected cutting cycle, some infected trees can be chosen as leave trees if: the tree is needed for stocking, is otherwise a desirable tree, the infection is light and only in the lower crown and the infection is not a threat to spread and intensification in surrounding trees of a lower height level.

This assumption provides more latitude in control procedures, but does not mean that sanitation can be cursory. Sanitation should still be as intensive as practical. **Unless the tree is vitally needed, it should be removed even though infection is confined to the lower crown.**

PRUNING DWARFMISTLETOE INFECTIONS



PRUNE ONLY IF SHOOTS ARE MORE THAN 6 INCHES FROM THE BOLE.

PRUNING IS COSTLY AND SHOULD BE AVOIDED IF POSSIBLE. USUALLY ONLY HIGH VALUE OR NECESSARY LEAVE TREES SHOULD BE PRUNED.

AVOID PRUNING TREES WITH THREE OR MORE INFECTED BRANCHES.

AVOID PRUNING INFECTIONS THAT ARE NOT DANGEROUS AS SOURCES OF SPREAD OR TO OVERALL TREE VIGOR.

CHART XX

PRUNING DWARF MISTLETOE INFECTIONS

Pathological pruning (removal of infected branches to sanitize a tree) can be used to supplement other silvicultural control operations. Most branch infections on young trees may be successfully eliminated by cutting the branch if the swelling at the site of the dwarf mistletoe shoots is more than 6 inches from the bole. This safety margin varies and is somewhat greater for large branches and for some host and parasite species.

Presently the policy in Region 2 is to do pathological pruning for dwarf mistletoe sanitation only when absolutely necessary. It should be considered as an incidental part of the total control job.

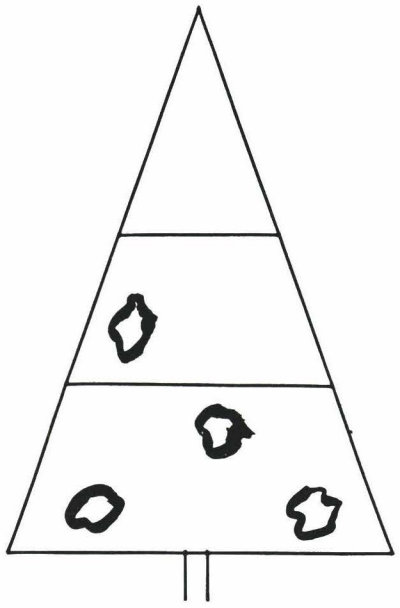
With some exceptions (e.g., if a lightly infected tree is far superior to its neighbors, or if its removal will leave a large gap in the stand), infected trees should not be selected for crop trees even if all visible infections can be removed. Pruning is expensive. The more heavily infected the tree, the more likely it is to bear latent or overlooked infections. Because of latent or small, difficult-to-see infections, pruning can be ineffective if performed too soon after overstory removal.

Nevertheless, in stands that are moderately to heavily infected, some trees with damaging infections may be left in order to maintain satisfactory stocking. On these trees some pathological pruning will be necessary to bring infection down to an innocuous level. If any leave tree selected for pathological pruning qualifies for silvicultural pruning, consideration should be given to pruning the tree bole clean to 8, 12, or 16 feet above stump height. In addition all dwarf mistletoe-infected branches should be pruned.

In general pathological pruning will have greater merit in recreational areas, special use areas and administrative sites than in commercial timber stands. In such instances where values warrant the cost, infections in large trees as well as small ones may be pruned out. If in recreational areas it is desirable to retain as many trees and as much tree crown as possible, spread of the parasite may be reduced by pruning out only the active infections producing female shoots. Old inactive infections not producing shoots and active ones that produce male shoots only can be left. Except for their capacity to start new infections, however, all infections are equally able to damage the host trees. Even though large, old brooms may not produce female shoots, it is usually desirable to remove them to help restore tree thrift.

Refer to "You Can Save Your Trees From Dwarf Mistletoe" by Hawksworth, Stewart, and Bailey, Research Paper RM-35, for control in high value trees.

INFECTION LEVELS OF DWARF MISTLETOE IN POLES AND MATURE TREES



DIVIDE CROWN IN THIRDS

↓

SCORE EACH THIRD
- NO INFECTION . . 0
- LIGHT INFECTION . 1
- HEAVY INFECTION . 2

↓

TOTAL SCORE IS INFECTION LEVEL

0, 1, 2	LOW LEVEL
3, 4	MEDIUM LEVEL
5, 6	HIGH LEVEL

LIGHT INFECTION—VERY FEW BRANCHES INFECTED. NO PROMINENT BROOMS.

HEAVY INFECTION—FEW TO MANY BRANCHES INFECTED, OR ONE OR MORE PROMINENT BROOMS.

NOTE: AN INFECTION ON THE TRUNK COUNTS THE SAME AS AN INFECTION ON A BRANCH.

CHART XXI

INFECTION LEVELS OF DWARF MISTLETOE IN INDIVIDUAL TREES

Steps to determine the infection level for an individual tree are outlined on the accompanying chart. This method serves as a guide for the field man, not as a rigid principle.

This method, developed at the Rocky Mountain Station, works best for pole-sized and larger-sized trees. Divide the live crown into thirds according to stem length. Do not attempt to divide on basis of surface area. For sapling-sized trees use the same procedure, except it may be better to divide the live crown in half and rate each half. In this case a score of 4 would be the maximum possible.

Poles and mature trees scoring 5 or 6 are generally growing at a slow rate and the chance of death is high; a 3 or 4 indicates a reduced growth rate but death is generally not imminent. Effect on growth of trees with a score of 1 or 2 is frequently slight or none, but such trees are a constant threat to surrounding trees. Within the tree itself the infection is rarely static; lightly infected trees become moderately infected and moderately infected ones become heavily infected.

For survey purposes and control operations in young growth stands, the ratio of number of infected trees to dwarf mistletoe-free trees on a stand basis may be of greater value than severity of infection in individual trees.

TIME OF YEAR FOR SURVEYS, MARKING AND CONTROL IS IMPORTANT

SURVEYS

DETECTION-THROUGHOUT THE YEAR WHEN VISIBILITY IS GOOD.

EVALUATION-JUNE 1 TO NOVEMBER 1.

MARKING

OVERSTORY-THROUGHOUT THE YEAR WHEN VISIBILITY IS GOOD.

UNDERSTORY-JUNE 1 TO NOVEMBER 1.

CONTROL OPERATIONS

IF PREMARKED-ANYTIME.

IF CUTTER'S CHOICE-JUNE 1 TO NOVEMBER 1.

CHART XXII

TIME OF YEAR FOR SURVEYS, MARKING AND CONTROL IS IMPORTANT

Surveys.—Detection surveys are made to determine the presence or absence of infection. They can be made at any time if visibility is good and branches are clear of snow. Evaluation surveys should be done during that part of the year when shoots are most obvious.

Marking.—Infected overstory trees are generally recognized by brooming or swollen branches rather than by dwarf mistletoe plants. Therefore, good visibility is the primary prerequisite for marking infected overstory trees. In infected understory trees brooms are often absent. Although infections may be recognized by swollen areas, the presence of plants is the best indication of infection. Thus, marking or selecting understory trees to cut or leave should be done during summer months or early fall.

Control operations.—Stand sanitation may be done any time if leave trees are premarked. If sanitation is by cutter's choice, the thinning-sanitation operation must be done when the dwarf mistletoe plants are most obvious.

CHARTS XXIII & XXIV

SUMMARY OF MAJOR GUIDELINES IN DWARF MISTLETOE CONTROL

Major dwarf mistletoe control guidelines given on the next two pages (Charts XXIII & XXIV) are offered as an over-simplified method to appraise the problem and arrive at an answer.

The forest manager, by evaluating the conditions he is faced with, arrives at the procedures he should follow. The evaluation shows him how to go about determining where, when, and how management control may be applied and places where it may not work.

As stated above, the guides are over-simplified. The forest manager must use all his knowledge, apply the procedures and alternatives presented throughout this training aid, then determine the approach that will achieve maximum attainable control consistent with other management objectives.

CONDITION

A. OVERSTORY ABSENT OR MERCHANTABLE OVERSTORY TO BE CLEARCUT

B. ADEQUATE UNDERSTORY PRESENT

C. GROWING STOCK PRINCIPALLY REPRODUCTION OR SAPLINGS

D. GROWING STOCK NEEDS THINNING . . . . . **#1.**

D. GROWING STOCK DOES NOT NEED THINNING . . . . . **#2.**

C. GROWING STOCK PRINCIPALLY POLES OVER 5'' DBH . . . . . **#3.**

B. NO OR INADEQUATE UNDERSTORY PRESENT . . . . . **#4 or #5.**

A. MERCHANTABLE OVERSTORY TO BE PARTIALLY CUT

B. ADEQUATELY STOCKED UNDERSTORY . . . . . **#6.**

B. NON-STOCKED OR POORLY STOCKED UNDERSTORY

C. OVERSTORY UNEVEN-AGED WITH SOME GOOD GROWING STOCK **#6.**

C. OVERSTORY EVEN-AGED AND OVER MATURE . . . . . **#7.**

PROCEDURE

#1. REMOVE MERCHANTABLE OVERSTORY IF PRESENT; DESTROY UNMERCHANTABLE OVERSTORY. THIN AND SANITIZE UNDERSTORY.

#2. REMOVE MERCHANTABLE OVERSTORY IF PRESENT; DESTROY UNMERCHANTABLE OVERSTORY.

#3. REMOVE MERCHANTABLE OVERSTORY IF PRESENT; DELAY CONTROL IN POLE UNDERSTORY UNTIL THEY ARE MERCHANTABLE SIZE.

#4. DELAY DWARF MISTLETOE CONTROL AS WOULD NOT PRESENTLY BE INCIDENTAL TO GOOD MANAGEMENT.

#5. REMOVE MERCHANTABLE OVERSTORY IF PRESENT; DESTROY UNMERCHANTABLE OVERSTORY. DESTROY INFECTED UNDERSTORY & REGENERATE.

#6. SANITIZE OVERSTORY; DO NOT THIN OR SANITIZE UNDERSTORY (DELAY CONTROL).

#7. SANITIZE OVERSTORY; REMOVE RESIDUAL OVERSTORY AS SOON AS REGENERATION IS ESTABLISHED.